

**Range Extensions for Two Mycoheterotrophic Orchids,  
*Gastrodia takeshimensis* and *G. flexistyloides* (Orchidaceae),  
outside their Type Locality**

KENJI SUETSUGU<sup>\*</sup>

*Department of Biology, Graduate School of Science, Kobe University, 1-1 Rokkodai, Nada-ku, Kobe, 657-8501, Japan. \*kenji.suetsugu@gmail.com (author for correspondence)*

During recent field surveys in the northern Ryukyus and herbarium investigations, I found several previously unknown populations of two mycoheterotrophic and cleistogamous orchids, *Gastrodia takeshimensis* and *G. flexistyloides* (Orchidaceae). They were previously considered to be endemic to Takeshima, Kagoshima Prefecture. Given that the continued discovery of new species and range extensions for known species of *Gastrodia* have been made from only a limited number of surveys in a small selection of sites, it is likely that more extensive surveys in the Ryukyu Islands during the flowering season could reveal much more precise data regarding the diversity and distribution of the species of *Gastrodia*.

Key words: *Gastrodia*, mycoheterotroph, new locality, Orchidaceae

The genus *Gastrodia* (Orchidaceae) comprises approximately 80 species of mycoheterotrophic orchids distributed throughout the temperate and tropical regions of Asia, Oceania, Madagascar and Africa (Chung & Hsu 2006, Chen *et al.* 2009, Hsu & Kuo 2010, Hsu & Kuo 2011, Hsu *et al.* 2012, Govaerts *et al.* 2016). Many species of section *Codonanthus* (Schlechter 1911, Tuyama 1967) produce inflorescences that are 3–15 cm in length at flowering (Chung & Hsu 2006). As is the case with most mycoheterotrophic species, the species occur in small populations and appear for a very short time during their reproductive period (Tuyama 1982, Suetsugu *et al.* 2012). Furthermore, detailed descriptions for some species of section *Codonanthus* are lacking, particularly for those described decades ago. Given the difficulties in accurately identifying them, it has been difficult to conduct adequate taxonomic studies of this group.

Despite these limitations, our recent botanical

surveys in the Ryukyu Islands have resulted in the discovery of several new species and new distribution records for section *Codonanthus* (e.g. Suetsugu 2015). Considering the richness of the mycoheterotrophic flora already discovered in the Ryukyu Islands (Yahara & Tsukaya 2008, Ohashi *et al.* 2008, Suetsugu 2013, 2014, 2015, 2016a, b, Suetsugu *et al.* 2012, 2013, 2014), it is likely that further surveys in these regions will further contribute to our knowledge of the mycoheterotrophic flora of Japan as a whole. Here I report the first known occurrences of *G. takeshimensis* and *G. flexistyloides* outside of their type localities and provide descriptions of them based on information derived from newly discovered specimens.

***Gastrodia takeshimensis*** Suetsugu in *Annales Botanici Fennici*, 50: 375 (2013) —Fig. 1A & B.

*Specimens examined*: JAPAN. Kagoshima Pref.,

Yakushima, along the Tabu River. 18 April 2015, *Suetsugu s.n.* (KYO); JAPAN. Kagoshima Pref., Yakushima, Yudomari. 18 April 2015, *Suetsugu s.n.* (KYO); JAPAN. Kagoshima Pref., Yakushima, Anbo. 18 April 2015, *Suetsugu s.n.* (KYO); JAPAN. Kagoshima Pref., Kuroshima, Katadomari. 16 April 2016, *Suetsugu s.n.* (KYO); JAPAN. Kagoshima Pref., Nakanoshima, 17 April 1935, *Naito s.n.* (KAG).

Herbs, terrestrial, mycoheterotrophic. Roots few, slender or occasionally thickened, mostly extending from apex of rhizome. Rhizome tuberous, fusiform or cylindrical, 2–9 cm long, 3–14 mm in diameter, pale brown, covered with numerous scales and unicellular hairs. Inflorescence erect, pale brown, 7–16 cm long, 2–3.5 mm in diameter, nodes 3 or 4, with tubular membranous sheaths. Bracts to 3.5 mm long, 3 mm wide. Pedicel and ovary to 15 mm long. Flowers 1–4, tubular, slightly erect or deflexed, resupinate, 16–20 mm long, 6–7 mm in diameter. Sepals and petals united to form a 5-lobed perianth tube, tube never opening during anthesis. Sepals subsimilar, fleshy, 16–20 mm long, connate with petals ca. 3/4 their length, lateral sepals connate with each other ca. 2/3 their length, outer surface dark brown, verrucous, margins entire; free portion of dorsal sepal straight, ovate-triangular, retuse, ca. 5 mm long, 5 mm wide; free portion of lateral sepals, triangular, retuse, apex acute. Free portions of petals ovate or elliptic, to 3.5 mm long, 3 mm wide. Lip joined with perianth tube, ca. 10 mm long; hypochile pale green, without appendages or calli; epichile reddish orange, ovate-elliptic, base contracted; central ridges 2, extending toward apex, margin slightly undulate; apex ligulate, red, ca. 1.5 mm wide. Column straight, semi-cylindrical, 7–8 mm long, ca. 2 mm wide, white; lateral wings (stelidia) distinct, narrow, edges parallel to column, base slightly angled, apex acute; rostellum absent. Anther hemispheric, 1–1.5 mm in diameter, pollinia 2. Capsule cylindrical, 3–3.5 cm long, pedicel elongating to ca. 30 cm long in fruit. Seeds fusiform, ca. 2 mm long.

Note: *Gastrodia takeshimensis* was previously considered to be endemic to Takeshima, Kagoshima Prefecture (Suetsugu 2013). Recent field

surveys in these regions and herbarium investigations showed that *G. takeshimensis* also occurs on other islands in the northern Ryukyus, including Yakushima, Kuroshima and Nakanoshima. In addition, while voucher specimens were not collected, photos taken by Koichi Kaburagi indicates that *G. takeshimensis* is also in Takatane on Tanegashima. Thus, *G. takeshimensis* may occur on other islands of the (especially northern) Ryukyus, from which there are currently no reports.

Specimens of *G. takeshimensis* from some of the Yakushima populations tend to be smaller than those from the type locality. Other than a shorter inflorescence (5–11 cm vs. 7–16 cm), there is no clear difference in either coloration or morphology, particularly with regard to the lip and column, which are important characteristics used in classifying the species of *Gastrodia*. Given their dependence on fungi for nutrition (Leake 1994), it is not surprising that individuals of *G. takeshimensis* vary in size, depending on environmental factors such as the activity of their symbiotic fungi. The relatively minor differences between the specimens from the type locality and those from Yakushima are therefore attributed to intraspecific variation.

The floral morphology of *G. takeshimensis* is similar to that of *G. nipponica*, although the former can be distinguished by its narrower and enclosed perianth tube (5–7 mm vs. 11–13 mm in diameter), its reproductive behavior (cleistogamous vs. chasmogamous) and its lip characteristics (2–4 ridges vs. 4–6 ridges). In addition, the lip of *G. takeshimensis* is joined with the perianth tube, while the lip of *G. nipponica* is adnate to the column foot. The hypochile of *G. takeshimensis* lacks appendages and calli, while *G. nipponica* produces two greenish, globose calli (Suetsugu 2013). It should be noted that some populations of *G. takeshimensis* on Yakushima co-occur with *G. nipponica*. The two species have different flowering seasons, with *G. takeshimensis* flowering somewhat later than *G. nipponica* (mid to late April vs. early to mid April).

***Gastrodia flexistylodes*** Suetsugu in Phytotaxa,



FIG.1. (A). Flowering plant of *Gastrodia takeshimensis* at Katadomari, Kuroshima, Kagoshima Pref., (B). Flowering plant of *G. takeshimensis* at Yudomari, Yakushima, Kagoshima Pref., (C). Flowering plant of *G. flexistyloides* at Osato, Kuroshima, Kagoshima Pref., (D). Herbarium specimen of *G. flexistyloides* at Iojima, Kagoshima Pref.

175: 270 (2014) —Fig. 1C & D.

*Specimens examined:* JAPAN Kagoshima Pref., Kuroshima, Katadomari. 16 April 2016, *Suetsugu s.n.* (KYO); JAPAN Kagoshima Pref., Kuroshima, Nakazato 16 April 2016, *Suetsugu s.n.* (KYO); JAPAN Kagoshima Pref., Kuroshima, Katadomari. 16 April 2016, *Suetsugu s.n.* (KYO); JAPAN Kagoshima Pref., Iojima, 16 April 1985, *T. Eitoku s.n.* (KAG).

Herbs, terrestrial, mycoheterotrophic. Roots few, slender or occasionally thickened, mostly extending from apex of the rhizome. Rhizome tuberous, fusiform or cylindrical, 2–8 cm long, 4–13 mm in diameter, pale brown, covered with numerous scales and unicellular hairs. Inflorescence erect, pale brown, 7–18 cm long, 2.5–5 mm in diameter, nodes 3 or 4, with tubular, membranous sheaths. Bracts to 8 mm long, 5 mm wide. Pedicel and ovary to 15 mm long. Flowers 1–6, tubular, slightly erect or deflexed, resupinate, 14–18 mm long, 5–6 mm in diameter. Sepals and petals united to form a 5-lobed perianth tube, which never opens during anthesis. Sepals subsimilar, fleshy, 14–18 mm long, connate with petals ca. 3/4 their length; lateral sepals connate with each other ca. 2/3 their length, outer surface pale brown, verrucose; free portion of dorsal sepal ovate-rectangular, apex retuse, ca. 4.5 mm long, 4 mm wide; free portions of lateral sepals ovate, ca. 4.5 mm long, 4.5 mm wide, apex obtuse. Free portion of petals pale orange, ovate, ca. 4 mm long, 3 mm wide, base contracted and thickened, margin slightly scabrous. Lip adnate to column foot, pale green, ca. 8–9 mm long, 4–5 mm wide; hypochile with 2 greenish, globose calli; epichile rhombic-ovate, base contracted, disc 4–6 ridged, with two central ridges extending toward the apex, margin slightly undulate; apex ligulate, red, ca. 1.5 mm wide. Column 3-lobed, lateral lobes erect, ca. 6 mm long, central lobe strongly incurved; column foot well developed; rostellum absent. Anther hemispheric, ca. 1 mm in diameter, pollinia 2. Capsule cylindrical, 3–3.5 cm long, pedicel elongating to ca. 30 cm long in fruit. Seeds fusiform, ca. 2 mm long.

**Note:** While *Gastrodia flexistylodes* was previously considered to be endemic to Takeshima,

Kagoshima Prefecture (Suetsugu 2014), recent field surveys and herbarium investigations showed that it occurs on Kuroshima and Iojima.

The most characteristic feature of *G. flexistylodes* is its trilobed column with a strongly incurved central lobe. Although this structure also occurs in the Taiwanese *G. flexistyla*, *G. flexistylodes* can be distinguished by its smaller perianth tube (14–19 mm vs. 19–24 mm), larger stature during flowering (7–18 cm vs. 3–6 cm), its reproductive mode (cleistogamous vs. chasmogamous), and narrower perianth tube (5–6 mm vs. 11–13 mm; Suetsugu 2014). *Gastrodia flexistylodes* is also similar in appearance to *G. takeshimensis*, since both species have completely cleistogamous flowers and elongate an corolla tube. However, the two species differ greatly in their lip and column morphology (Suetsugu 2013, 2014), and can also be distinguished without dissection based on the color of the perianth tube, which is pale brown in *G. flexistylodes* and dark brown in *G. takeshimensis*. Furthermore, *G. flexistylodes* flowers somewhat earlier than *G. takeshimensis* (mid-March to early April vs. mid-April to late April).

The continued discovery of new species of *Gastrodia* and range extensions for known species in the Ryukyu islands indicate that a large number of undescribed species could still remain within the area. Considering that these discoveries resulted from a limited number of surveys in a small number of sites (e.g. Suetsugu *et al.* 2012, 2013, 2014, Suetsugu 2012, 2013, 2014, 2016a, 2016b), it is likely that more extensive surveys during the flowering season may reveal more precise data regarding the diversity and distribution of the species of *Gastrodia*. Such detailed accounts could prove critical for conserving the species of *Gastrodia* section *Codonanthus* in southern Japan.

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gashima. I also thank the curators of KAG for access to the herbarium specimens in their care. This work was supported by a grant-in-aid from the Japan Society for the Promotion of Science (15K18470).

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